6

LOWER DEVONIAN CONODONTS FROM THE TYERS AREA, GIPPSLAND, VICTORIA

By G. M. Philip

Geology Department, University of New England

Abstract

Thirty-four disjunct conodont species extracted from the Coopers Creek Formation, Tyers district, Gippsland, are described and figured. New taxa proposed are *Belodus resimus* sp. nov., *Eognathodus sulcatus* gen. et sp. nov., *Eognathodus secus* gen. et sp. nov., *Paltodus valgus* sp. nov. The known ranges of species common to the Tyers fauna and Europe indicate an Upper Gedinnian or Siegenian age for the Coopers Creek Formation.

Introduction

Apart from Crespin's (1943) initial description of a small Ordovician fauna from Central Australia, no systematic studies of Australian conodont faunas have yet been published, although their occurrence has been reported from strata ranging in age from Cambrian to Permian (Cambrian—Jones 1961; Ordovician—Guppy and Öpik 1950; Öpik 1954, 1958; Glenister and Glenister 1957b; Silurian—Glenister and Glenister 1957a; Devonian—Glenister and Crespin 1959; Carboniferous—Glenister 1962; Permian—Glenister and Furnish 1961). Research on the distribution of conodonts in Europe and N. America, particularly over the last decade, has indicated their outstanding value in biostratigraphical studies. Current work on this group of tooth-like microfossils in the University of New England has revealed their widespread occurrence in eastern Australia, and their importance in stratigraphical correlations.

The present study deals with the description and stratigraphical significance of conodonts from the Lower Devonian limestone outcropping along the Tyers R., Gippsland. Occurring with the conodonts are undoubted vertebrate remains. As these represent the oldest known vertebrates recorded from the Australian continent they are described in a separate section of this paper.

A University of New England Research Grant (No. 120) which covered both field and laboratory expenses is most gratefully acknowledged. I am greatly indebted to Dr O. H. Walliser, Philipps-Universität, Marburg (Lahn), whose comments on a draft of the manuscript led to a revision of a number of earlier identifications. Professor F. H. T. Rhodes, of the University College of Swansea, also provided me with much useful information relating to work on conodonts, and translations of some of the German conodont literature.

Method of Study

The conodonts described in this study were extracted from limestone collected from the old Tyers Limestone Quarry, on the E. bank of the lower Tyers R., Gippsland. This is given as fossil locality No. 11 by Philip (1962, Fig. 1). The different lithologies exposed in the quarry were sampled. These ranged from mid-grey bioclastic calcarenites to very dark grey calcilutites. A total sample of some 20 kg was collected and processed.

The limestone was digested in a 10 to 15% solution of commercial acetic

acid. The insoluble residue was washed and screened under water. Conodonts were contained in the material which passed through a 22 mesh-per-inch screen but which was retained on a 120 mesh-per-inch screen. This residue was dried and placed in tetrabromethane (diluted with alcohol to a specific gravity of 2·75). The portion of the sample which sank in this heavy liquid was washed in alcohol and dried, and the conodonts removed under a binocular microscope with the aid of a fine sable brush. Specimens were then mounted on microslides with gum tragacanth to which chlorocresol had been added to prevent fungal growth.

In all, some 600 identifiable conodonts were recovered from the 20 kg of limestone processed. The average abundance of 30 per kg is similar to the abundances given by Collinson (1963) for N. American Devonian and Carboniferous limestones, and compares very favourably with many other Australian Devonian limestones which have been processed. Certain Ordovician limestones from Central Australia, however, have yielded an estimated 30,000 conodonts per kg. This prolific occurrence is probably the greatest abundance of conodonts yet reported from a limestone. Second to it is the record of Bischoff and Ziegler (1957) who found a concentration of over 23,000 specimens per kg in a limestone in the lower *Cheiloceras* Stufe of Germany.

The illustrations were obtained by using a 'Leica' camera adapted to give a negative diameter of × 10 with a 40 mm lens. Text-figures were prepared from specimens with the aid of a binocular microscope with a graticuled eyepiece and also from photographs. All photographed specimens are registered in the Palaeontological Collection of the University of New England, Armidale, N.S.W.

Composition of Fauna

Listed below are the 34 disjunct conodont species present in the fauna. The number of identifiable specimens of each form recovered from the residue is also given.

Belodus resimus sp. nov.	55
B. cf. *triangularis* Stauffer	12
Eognathodus sulcatus gen. et sp. nov.	87
E. secus gen. et sp. nov.	2
E. sp.	3
Hindeodella equidentata Rhodes	5
H. priscilla Stauffer	21
Icriodus bilatericrescens Ziegler	1
Lonchodina greilingi Walliser	4
L. walliseri Ziegler	2
Neoprioniodus bicurvatus (Branson & Mehl)	17
N. excavatus (Branson & Mehl)	6
N. (?) sp.	1
Ozarkodina denckmanni Ziegler	42
O. media Walliser	14
O. sp. A	6
O. (?) sp. B	2
Paltodus acostatus Branson & Branson	63
P. cf. *recurvatus* Rhodes	4
P. unicostatus Branson & Mehl	17
P. valgus sp. nov.	28
P. sp. A	6

P. sp. B	1
Plectospathodus alternatus Walliser	3
P. extensus Rhodes	8
P. sp.	6
Spathognathodus inclinatus wurmi Bischoff & Sannemann	14
S. steinhornensis steinhornensis Ziegler	134
Trichonodella inconstans Walliser	33
T. symmetrica (Branson & Mehl)	7
T. sp. nov.	1
Gen. et sp. indet. A	14
Gen. et sp. indet. B	1
Gen. et sp. indet. C	2

Stratigraphic Significance of Fauna

I have previously concluded that the age of the shelly fossil fauna at the top of the Boola Beds is Lower Gedinnian (Philip 1962, p. 244-6). This unit underlies the Coopers Creek Formation which, on the western limb of the Tyers anticline, consists of a basal conglomeratic phase which grades up into limestone from which the conodont fauna here described was recovered. The Coopers Creek Formation, in turn, is overlain by a sparsely fossiliferous greywacke sequence (the Walhalla Beds) from which, in this area, only plant remains have been recovered.

The Lower Gedinnian age assigned to the Boola Beds was deduced from the known ranges of brachiopod genera present in the fauna (Boucot 1960, Table 1). At an earlier stage an Upper Ludlovian age had been ascribed to these and similar faunas (Philip 1960) but, following Boucot's restudy of the Gedinnian brachiopods of Belgium, it was necessary to revise this opinion.

Although detailed mapping suggests disconformity or slight angular unconformity between the Boola Beds and the Coopers Creek Formation (Philip 1962, p. 125, fig. 1), previously I have considered that no marked diastem exists between the units (Philip 1960, p. 148). This conclusion was based in part on the similarity between the faunas of the Boola Beds and those of other limestones of the Walhalla Synclinorium. However, additional consideration of the problems presented by the area indicates the likelihood of a disconformity, probably of regional significance, at the base of the Coopers Creek Formation.

It therefore becomes critical to an understanding of the sequence of Australian Devonian faunas to establish unequivocably the Lower Devonian age of the Coopers Creek Formation in the Tyers area. The conodont fauna provides such evidence.

Knowledge of the sequence of late Silurian and Lower Devonian conodont faunas in Europe and N. America derives principally from the studies of Bischoff and Sannemann (1958), Jentzsch (1962), Rhodes (1953), Walliser (1957, 1960, 1962, 1964), and Ziegler (1956, 1960, 1962). Available information has been summarized by Walliser (1962, 1964) who has proposed a zonal scheme of faunas which, for the upper part of the Lower Devonian, is based on otherwise unpublished information.

According to the ranges given by Walliser, seven of the species present in the Tyers fauna appear in the Silurian and range through to the top of the Lower Emsian. These are *Hindeodella equidentata* Rhodes, *Lonchodina greilingi* Walliser, *Neoprioniodus excavatus* (Branson and Mehl), *Ozarkodina media* Walliser, *Plectospathodus extensus* Rhodes, *Spathognathodus inclinatus* (Rhodes), and *Trichonodella inconstans* Walliser. Other species which are known to extend well into the

Lower Devonian (probably with a similar range) are *Neoprioniodus bicurvatus* (Branson and Mehl), *Lonchodina walliseri* Ziegler, *Plectospathodus alternatus* Walliser, and *Trichonodella symmetrica* (Branson and Mehl). *Ozarkodina denckmanni* Ziegler also sees its origin in the late Silurian but ranges through the entire Lower Devonian. Within the Lower Devonian, an age younger than Lower Gedinnian is established by the occurrence of *Spathognathodus steinhornensis steinhornensis* Ziegler and *Icriodus bilatericrescens* Ziegler, whereas the absence of polygnathids indicates an age older than Lower Emsian.

It is concluded, therefore, that the Coopers Creek Formation is either Upper Gedinnian or Siegenian. A more precise correlation anticipates the results of current work on other Australian Devonian conodont faunas. However, it seems that an age within the lower part of this interval is indicated by the Tyers fauna, i.e. Upper Gedinnian or early Siegenian.

Systematics

Genus **Belodus** Pander 1856

TYPE SPECIES: *Belodus gracilis* Pander 1856.

REMARKS: *Belodus* includes essentially fang-like conodonts often with a greatly enlarged basal cavity. The lateral faces are usually costate or grooved, and the posterior edge has a series of small denticles.

Belodontids and distacodontids (such as *Paltodus*) form a significant element of the Tyers conodont fauna. Many authors have urged that the occurrence of such forms in Devonian faunas is indicative of stratigraphic admixture (e.g. Rhodes & Dineley 1957), for such simple conodonts are more characteristic of Ordovician strata. However, over the last 10 years there have been a number of new records of Upper Silurian and Devonian occurrences of such forms. In the Australian Lower Devonian they are a widely distributed and numerically important element of all conodont faunas so far studied. As these faunas have been recovered from geographically widely separated localities in different geological settings, these simpl . conodonts are interpreted as an integral part of Australian Devonian conodo .e faunas. .nt

Ethington (1959) proposed *Belodella* (type species, *Belodus devon*· Stauffer) for Devonian forms with deep basal cavities previously include· *icus Belodus*. However, for the purposes of the present descriptions, this genus ha .d in been recognized. .s not

Belodus resimus sp. nov.

(Fig. 2 e-f; Pl. 8, fig. 15-17, 19)

DIAGNOSIS: A species of *Belodus* with a deep basal cavity which i· triangular in cross section. Junctions of the anterior and lateral faces .s narrowly costae; numerous small denticles along the posterior edge. , r narked by

TYPE SPECIMENS: Holotype 8798/15; paratypes 8798/16, 18.

DESCRIPTION: The unit is progressively arched posteriorly and is continued above the basal portion as a long tapering process. The basal extends almost to underneath the distal process. The cross cavity is deep and cavity is narrowly triangular with a narrow anterior face. section of the basal projected laterally as flanges which distally tend to be . This anterior face is prominent. About 40 closely spaced fused denticles come thicker and more posterior edge. Some specimens are bowed laterally. are mounted along the

REMARKS: The specimen illustrated by Rhodes & Dineley (1957, Pl. 37, fig. 3) as *B.* cf. *B. devonicus* Stauffer in lateral view closely resembles *B. resimus*. These authors note that their form may be laterally bowed, which suggests further comparison with our species. However, in *B. devonicus* Stauffer the anterior margin is strongly keeled.

Belodus triangularis Stauffer

Belodus triangularis Stauffer 1940, p. 420, Pl. 59, fig. 49.
Belodus triangularis Stauffer, Rhodes & Dineley 1957, p. 358, Pl. 37, fig. 1-2.
non *Belodus triangularis* Stauffer, Bischoff & Sannemann 1958, p. 94, Pl. 15, fig. 8-9.
nec *Belodus triangularis* Stauffer, Jentzsch 1962, p. 964, Pl. 1, fig. 2-3.

DIAGNOSIS: A species of *Belodus* having a deep basal cavity and a strongly triangular cross section. Junctions of lateral and anterior faces marked by ridges; numerous small denticles along the posterior edge.

Belodus cf. **triangularis** Stauffer

(Fig. 2 c-d; Pl. 8, fig. 22, 26-28)

FIGURED SPECIMENS: 8798/19-22.

REMARKS: Stauffer's original illustration of this species is of a fragmentary specimen in which the shape of the distal termination is inferred. In the Tyers specimens this termination is more strongly recurved than in Stauffer's reconstruction. However, specimens in which the distal end has been broken (e.g. Pl. 8, fig. 22) resemble closely Stauffer's actual specimen, and in other respects our material agrees closely with this species.

If the complete specimen illustrated as *B. triangularis* by Rhodes & Dineley (1957, Pl. 37, fig. 1) is indeed this species, then the Tyers form is not conspecific with *B. triangularis*. The other broken specimen illustrated by them (op. cit. Pl. 37, fig. 2) appears to approach more closely Stauffer's original figure and the Tyers form. Bischoff & Sannemann (1958) and Jentzsch (1962) have figured long tapering forms which apparently resemble *B. resimus* described above.

Genus **Eognathodus** gen. nov.

TYPE SPECIES: *Eognathodus sulcatus* sp. nov.

DIAGNOSIS: Platformed conodonts with a greatly expanded and flaring basal cavity located at the posterior end of the unit. Anterior blade high and denticulate, merging with the irregular nodes of the oral surface which may form lateral longitudinal rows, or be irregularly disposed. Aboral surface of unit shallowly excavated.

REMARKS: *Eognathodus* strongly resembles Carboniferous platformed genera such as *Gnathodus* and *Streptognathus* in the development of a wide posteriorly situated basal cavity or cup. From *Gnathodus* it differs obviously in lacking the continuation of the blade across the platform as a carina, and so it more closely resembles the Upper Carboniferous form *Streptognathus*. This resemblance is particularly marked in the type species *Eognathodus sulcatus* for, in this species, the nodes are arranged in two lateral rows with a trough-like depression formed along the axis of the platform. In *Streptognathus*, however, the platform is narrow and the basal cavity less expanded; moreover, the platform is ornamented with transverse ridges rather than nodes.

Bispathodus Müller (1962) (based on *Spathodus spinulicostatus* Branson) is

a form of *Spathognathodus* with a thickened blade in which the denticles are replaced by small transverse ridges. In other features it is identical with *Spathognathodus* so that here it is considered as a synonym of this latter genus. Other species which are included in *Spathognathodus* resemble more closely *Eognathodus* in that a definite double series of denticles may be developed along the oral margin of the blade, e.g. *Spathognathodus bipennatus* Bischoff & Ziegler (1957, p. 115-116, Pl. 21, fig. 31 a-c). In such species no true platform is developed and the basal cavity is centrally located. The resemblance to immature specimens of *Eognathodus sulcatus*, however, is most marked.

Eognathodus does not resemble closely the Silurian and early Devonian platformed genera *Kockelella* Walliser and *Ancyrodelloides* Bischoff & Sannemann. *Kockelella* is more similar to *Gnathodus* in possessing a posterior carina, whereas *Ancyrodelloides* has a restricted central basal cavity. Together with these genera, however, *Eognathodus* undoubtedly represents early platformed offshoots from the spathognathodid stock which apparently also gave rise to later platformed genera (cf. Müller 1962a, b).

Eognathodus is widely distributed through Australian Lower Devonian strata but does not appear to be represented elsewhere.

Eognathodus sulcatus sp. nov.

(Fig. 1; Pl. 10, fig. 17-18, 20-21, 24-25)

DIAGNOSIS: A species of *Eognathodus* with the ornament of the platform arranged in two irregular lateral series of nodes so that a medial trough is developed.

TYPE SPECIMENS: Holotype 8797/28; paratypes 8797/29-32.

DESCRIPTION: The unit is straight or slightly bowed outwards in plan view with the platform between 1·5 and 3 times the length of the shaft. The regularly denticulate blade is high anteriorly and tapers towards the platform. It usually merges with the platform well to the anterior of the flared margins of the basal cavity.

The platform is well differentiated, with vertical sides, and becomes progressively wider with increase in size. It is ornamented with closely spaced nodes which are arrayed in two irregular longitudinal series so that a medial groove is present. The platform tapers to a rather pointed posterior end, is usually somewhat constricted at midlength, and anteriorly is expanded to one side so that here it is markedly asymmetrical. The denticles of the blade tend to merge with the longitudinal series of platform nodes on the non-expanded side.

The aboral surface is excavate, with an asymmetrical basal cavity which is continued to the anterior end of the blade as a tapering groove (Fig. 1b).

REMARKS: This species and *Spathognathodus steinhornensis* are the most abundant forms in the material recovered.

Eognathodus secus sp. nov.

(Pl. 10, fig. 22-23)

DIAGNOSIS: A species of *Eognathodus* with the platform ornamented with irregular nodes.

TYPE SPECIMEN: 8797/34.

REMARKS: Two specimens in the collection differ from *E. sulcatus* in the following characters:

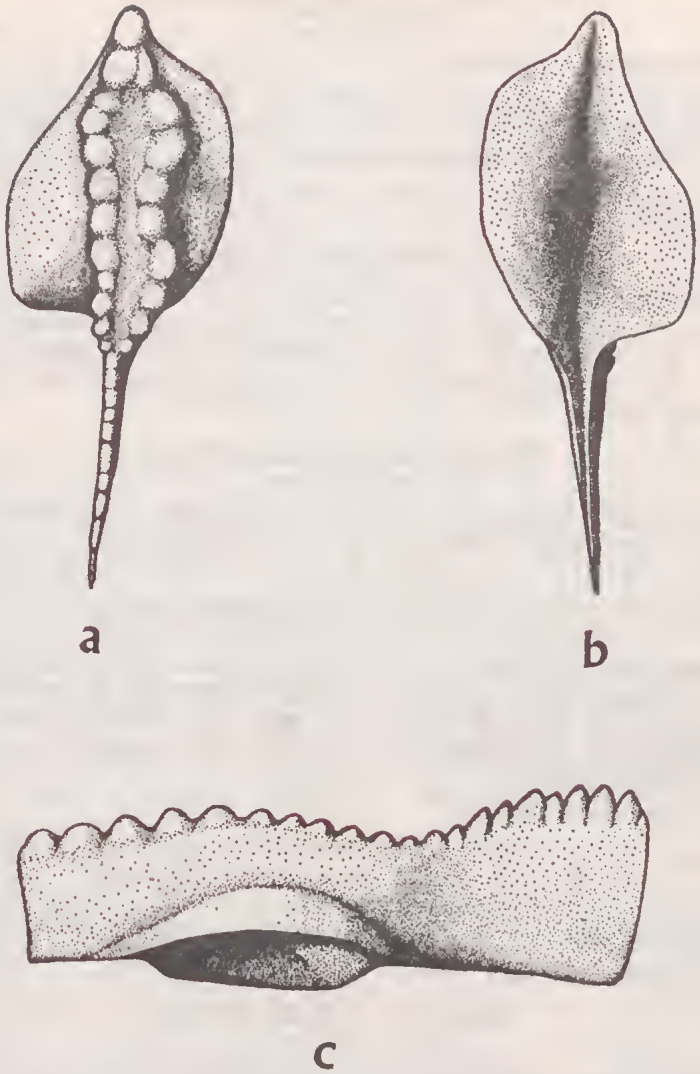

FIG. 1—*Eognathodus sulcatus* gen. et sp. nov. (a) Oral, (b) Aboral, (c) Lateral views, × 50.

(1) The nodes of the oral surface of the platform are irregular both in size and shape so that no medial trough is developed.

(2) The platform is relatively broader and the posterior shaft is thicker. The nodes of the platform continue up the postcrior end of the shaft.

(3) The basal cavity is shallower.

It is possible that these specimens merely represent variants of *E. sulcatus* and that a gradation may be found with that form. They are, however, morphologically so distinctive that their separation as a different species seems justified.

Eognathodus sp.

(Pl. 10, fig. 19)

FIGURED SPECIMEN: 8797/33.

REMARKS: In the available material three fragmentary specimens possess narrow, poorly differentiated platforms and widely expanded basal cavities. The ornament of the platform continues up the oral surface of the thick blade.

These forms again may represent variants of one or other of the previously described species.

Genus **Hindeodella** Bassler 1925

TYPE SPECIES: *Hindeodella subtilis* Bassler 1925.

REMARKS: Included in *Hindeodella* are laterally compressed bars with closely set denticles (commonly with a group of smaller denticles alternating with larger ones) and a short deflected anterior bar. The cusp is generally well developed and the basal cavity small.

Hindeodella equidentata Rhodes

(Pl. 8, fig. 11)

Hindeodella equidentata Rhodes 1953, p. 303, Pl. 23, fig. 248, 252-4; Walliser 1957, p. 34, Pl. 2, fig. 23; Ziegler 1960, p. 182-3, Pl. 15, fig. 10; Jentzsch 1962, p. 965, Pl. 2, fig. 10-11; Ethington & Furnish 1962, p. 1267-8, Pl. 173, fig. 2; Walliser 1962, p. 282, fig. 1 (8); Walliser 1964, p. 36, Pl. 8, fig. 3, Pl. 32, fig. 11.
Hindeodella affin. *equidentata* Rhodes, Bischoff & Sannemann 1958, p. 94, Pl. 15, fig. 2.
Hindeodella cf. *H. equidentata* Rhodes, Walliser 1960, p. 30, Pl. 8, fig. 15.

DIAGNOSIS: A massive species of *Hindeodella* with a thick deep bar and discrete denticles which generally lack smaller interposed denticles. Anterior bar short and inwardly bowed at an angle of between 90° and 120° to the posterior bar. A basal groove extends along the underside of the bar and is expanded only slightly to give the small basal cavity.

FIGURED SPECIMEN: 8797/3.

REMARKS: The Tyers specimens of this species have small denticles interposed between the larger denticles of the posterior bar, particularly toward the cusp. This is also true of the specimen illustrated as *H.* affin. *equidentata* Rhodes by Bischoff & Sannemann (loc. cit.). The feature may afford a basis for the separation of stratigraphically older and younger forms of the species.

Hindeodella priscilla Stauffer

(Pl. 8, fig. 13-14, 24-25)

Hindeodella priscilla Stauffer 1938, p. 429, Pl. 50, fig. 6; Bischoff & Ziegler 1957, p. 60, Pl. 7, fig. 1-5; Bischoff & Sannemann 1958, p. 94-5, Pl. 15, fig. 1; Jentzsch 1962, p. 965, Pl. 2, fig. 3; Walliser 1964, p. 36, Pl. 9, fig. 12, Pl. 32, fig. 12-13.
Hindeodella lambtonensis Stauffer 1938, p. 428, Pl. 50, fig. 2, 5, 8, 13, 14, 17, 20, 25, 28, 31.
Hindeodella milleri Stauffer 1938, p. 428, Pl. 50, fig. 3-4, 9-11.
Hindeodella moweri Stauffer 1940, p. 424, Pl. 58, fig. 2, 10-11.
Hindeodella n.sp. Walliser, Ziegler 1960, p. 183, Pl. 15, fig. 3-4.
Hindeodella n.sp. Walliser 1960, p. 30, Pl. 8, fig. 6.

DIAGNOSIS: A thin, moderately large species of *Hindeodella* with a long straight posterior bar, and a short, deflected anterior bar (which may be somewhat downwardly flexed), with usually discrete denticles. Posterior denticles hindeodellid, becoming larger posteriorly. Cusp round in cross section, inclined posteriorly and slightly bent; basal cavity small.

FIGURED SPECIMENS: 8797/4-5, 9, 11.

Genus **Icriodus** Branson & Mehl 1938

TYPE SPECIES: *Icriodus expansus* Branson & Mehl 1938.

REMARKS: *Icriodus* is a platformed conodont in which the whole of the aboral surface is deeply excavated. No true blade is developed, and the oral surface is ornamented with a regular series of nodes. Lateral processes which expand the basal cavity may originate from the posterior end and these may bear series of nodes similar to those of the platform.

Müller (1962a) has proposed the genus *Latericriodus* to include those species of *Icriodus* which possess lateral processes. Such a division of *Icriodus* does not seem to be warranted at present and so this genus has not been used. In Europe and N. America, *Icriodus* is widely distributed through Devonian strata. It is apparently very much rarer in eastern Australia as only a few specimens have been observed in various conodont faunas which have been studied.

Icriodus bilatericrescens Ziegler

(Pl. 9, fig. 30-32)

Icriodus latericrescens bilatericrescens Ziegler 1956, p. 101, Pl. 6, fig. 6-13; Bischoff & Sannemann 1958, p. 96, Pl. 12, fig. 5; Jentzsch 1962, p. 966, Pl. 1, fig. 12a-b, 14, 24.
Icriodus latericrescens latericrescens Branson & Mehl, Ziegler 1956, p. 100-101, Pl. 6, fig. 14-17; Bischoff & Sannemann 1958, p. 95, Pl. 12, fig. 8; Jentzsch 1962, p. 967, Pl. 1, fig. 16.
Icriodus latericrescens cf. *latericrescens* Branson & Mehl, Bischoff & Sannemann 1958, p. 95-96, Pl. 12, fig. 10-11.
Latericriodus bilatericrescens (Ziegler) Müller 1962a, p. 115.
Icriodus latericrescens cf. *bilatericrescens* Ziegler, Jentzsch 1962, p. 966, Pl. 1, fig. 10a-b, 13, 15.
Icriodus woschmidti Ziegler, Jentzsch 1962, p. 967, Pl. 1, fig. 17-23.
Icriodus latericrescens Ziegler (non Branson & Mehl), Walliser 1962, p. 282, fig. 35 (1).
non *Icriodus latericrescens* Branson & Mehl 1938, p. 164-165, Pl. 26, fig. 30-37.
nec *Icriodus woschmidti* Ziegler 1960, p. 185-186, Pl. 15, fig. 16-18, 20-22.

DIAGNOSIS: A species of *Icriodus* with a posteriorly expanded basal cavity bearing one or sometimes two, spur-like series of nodes arising from the posterior denticle. Ornament of platform consists of nodes arranged in transverse ridges which become crowded posteriorly.

FIGURED SPECIMEN: 8797/25.

REMARKS: Walliser (1962) and Orr (1964) have noted that the Lower Devonian form identified as *I. latericrescens* Branson & Mehl by Ziegler (1956) differs from the Middle and Upper Devonian form. In the Lower Devonian material the nodes of the platform are arranged in transverse ridges and the lateral spur(s) is much less strongly ornamented. For the present both are regarded as separate species and the name *I. bilatericrescens* Ziegler is employed for the Lower Devonian form. This was introduced as a subspecies of *I. latericrescens* sensu Ziegler for forms which possess two lateral spurs, but it is clear that both forms are gradational.

Dr O. H. Walliser (in litt. March 1965) has re-examined the material identified by Jentzsch (loc. cit.) as *I. woschmidti* and would rather include the form in *I. latericrescens* sensu Ziegler. This re-identification of the Thuringian specimens is given in the synonymy above, and permits confident identification of the single specimen from Tyers.

Genus **Lonchodina** Bassler 1925

TYPE SPECIES: *Lonchodina typicalis* Bassler 1925.

REMARKS: *Lonchodina* includes asymmetrical, twisted, and usually arched units. The denticles are generally long, cylindrical, and discrete. Most described species have a large basal cavity.

Lonchodina greilingi Walliser

(Pl. 9, fig. 22)

Lonchodina greilingi Walliser 1957, p. 38, Pl. 3, fig. 20-26; Walliser 1960, p. 31, Pl. 8, fig. 17-18; Ziegler 1960, p. 188, Pl. 14, fig. 15-16, 18, 20; Ethington & Furnish 1962, p. 1274, Pl. 173, fig. 10; Walliser 1962, p. 283, fig. 1 (22); Walliser 1964, p. 44, Pl. 8, fig. 7, Pl. 30, fig. 7-8.

DIAGNOSIS: A strongly arched species of *Lonchodina*, the limbs of which are somewhat twisted and bear rounded discrete denticles. Cusp somewhat posteriorly inclined, rounded in section, with base projecting inwards from the limbs; unit excavated beneath cusp to give the basal cavity which extends slightly up the inner side of the cusp.

FIGURED SPECIMEN: 8797/16.

REMARKS: This form differs from *Trichonodella inconstans* Walliser principally in its somewhat twisted, asymmetrical nature. The Tyers material resembles most closely the specimen illustrated by Walliser 1964, Pl. 30, fig. 8.

Lonchodina walliseri Ziegler

(Pl. 8, fig. 35)

Lonchodina n.sp.b Walliser 1957, Pl. 3, fig. 27-28.
Lonchodina walliseri Ziegler 1960, p. 188, Pl. 14, fig. 1, 3, 7; Walliser 1964, p. 44-45, Pl. 8, fig. 17, Pl. 30, fig. 26-33.

DIAGNOSIS: A species of *Lonchodina* with the posterior limb usually of length similar to the posterior limb. Limbs twisted, with slightly compressed, discrete denticles. Underside of unit flattened with the anterior limb usually tapering anteriorly; posterior limb with thickened aboral margins. Basal cavity developed as a pit beneath the cusp.

FIGURED SPECIMEN: 8797/13.

REMARKS: Although only a few fragmentary specimens of this form were recovered, little doubt can be entertained as to its identity.

Genus **Neoprioniodus** Rhodes & Müller 1956

TYPE SPECIES: *Prioniodus conjunctus* Gunnell 1933.

REMARKS: This genus was proposed for forms with the cusp at the anterior end of a denticulated bar. An anticusp or a very short anterior bar may be present and this may bear small denticles.

There is, however, no general agreement as to the generic assignment of conodonts with these characters. European workers tend to regard *Neoprioniodus* as a synonym of *Prioniodina* Ulrich & Bassler, whereas N. American authors maintain that *Neoprioniodus* is separable. Lindström (1959), on the other hand, considers that *Neoprioniodus* is a synonym for *Cordylodus* Pander, but Lindström (1964) later accepted the validity of *Neoprioniodus*.

For present purposes the genus *Neoprioniodus* is employed without prejudice for the Silurian and younger conodonts which conform to the above description.

Walliser (1964) has revised the earlier identifications of the common Silurian and Lower Devonian species *N. excavatus* (Branson & Mehl) and *N. bicurvatus* (Branson & Mehl) and his interpretations have been followed here.

Neoprioniodus bicurvatus (Branson & Mehl)

(Pl. 9, fig. 13, 18, 20)

Prioniodus bicurvatus Branson & Mehl 1933, p. 44, Pl. 3, fig. 9-12.
Prioniodina tropa (Stauffer) Ziegler 1956, p. 104, Pl. 16, fig. 29, Pl. 7, fig. 29.
Prioniodina bicurvata pronoides Walliser, Ziegler 1960, p. 33, Pl. 8, fig. 8-10.
Prioniodina n.sp. Ziegler 1960, p. 193, Pl. 16, fig. 23.
Prioniodina bicurvata pronoides Walliser 1960, p. 33, Pl. 8; Jentzsch 1962, p. 971, Pl. 2, fig. 13.
Neoprioniodus sp. Ethington & Furnish 1962, p. 1275, Pl. 173, fig. 3.
Neoprioniodus bicurvatus (Branson & Mehl) Walliser 1964, p. 46, Pl. 9, fig. 13, Pl. 29, fig. 27-33; Fig. 1.
non *Synprioniodina tropa* Stauffer 1940, p. 434, Pl. 59, fig. 60.
nec *Prioniodina bicurvata* (Branson & Mehl) Walliser 1957, p. 46, Pl. 2, fig. 18-19.
nec *Prioniodina bicurvata* (Branson & Mehl) Bischoff & Sannemann 1958, p. 102, Pl. 15, fig. 6, 12.
nec *Prioniodina bicurvata* (Branson & Mehl) Ethington & Furnish 1962, p. 1283, Pl. 173, fig. 17.
nec *Prioniodina bicurvata* (Branson & Mehl) Walliser 1962, p. 283, fig. 1 (17).

DIAGNOSIS: A species of *Neoprioniodus* with closely spaced denticles which are forwardly directed in relation to the base of the posterior bar. Cusp enlarged with a flattened outer surface; aboral surface of posterior bar usually with a longitudinal groove which expands to give a well defined basal cavity beneath the cusp; anticusp small and may bear several tiny denticles.

FIGURED SPECIMENS: 8797/55-57.

REMARKS: The Tyers material agrees closely with Walliser's (1964) interpretation of this species.

Neoprioniodus excavatus (Branson & Mehl)

(Pl. 9, fig. 16-17)

Prioniodus excavatus Branson & Mehl 1933, p. 45, Pl. 3, fig. 7-8.
Prioniodina bicurvata (Branson & Mehl) Walliser 1957, p. 46, Pl. 2, fig. 18-19; Bischoff & Sannemann 1958, p. 102, Pl. 15, fig. 6, 12; Ethington & Furnish 1962, p. 1283, Pl. 173, fig. 17; Walliser 1962, p. 283, fig. 1 (17).
Neoprioniodus excavatus (Branson & Mehl) Walliser 1964, p. 49, Pl. 8, fig. 4, Pl. 29, fig. 26; Fig. 5c.
non *Prioniodus bicurvatus* Branson & Mehl 1933, p. 44, Pl. 3, fig. 9-12.

DIAGNOSIS: A species of *Neoprioniodus* with closely spaced denticles, sometimes alternating in size, directed normally to the posterior limb. Cusp flattened on outer side, with sharp anterior margin projected as an anticusp which may bear small denticles. Basal cavity usually not continued as groove beneath the posterior bar.

FIGURED SPECIMENS: 8798/53-54.

Neoprioniodus (?) sp.

(Pl. 9, fig. 14)

FIGURED SPECIMEN: 8798/7.

REMARKS: In this form the posterior limb is gently arched and bears regular, widely spaced denticles. The anterior limb is short, tapers to a point and bears small separate denticles. The aboral surface is marked by a longitudinal groove which expands under the cusp to give the basal cavity.

Neoprioniodus latidentatus Walliser 1964 (p. 50, Pl. 29, fig. 34-35) possesses similar denticulation of the posterior limb, but lacks the well defined anticusp (or anterior limb) with well spaced, discrete denticles. This latter feature also prevents unequivocal asignment to *Neoprioniodus*, and suggests that the form may be better referred to *Lonchodina*.

Genus **Ozarkodina** Branson & Mehl 1933

TYPE SPECIES: *Ozarkodina typica* Branson & Mehl 1933.

REMARKS: *Ozarkodina* is employed for flattened bar-like units with a comparatively small subapical basal cavity.

Although Hass (1962) includes Ordovician species in the genus, these possess a large longitudinal basal excavation. It seems preferable to follow Sweet et al. (1959) in restricting *Ozarkodina* to Silurian and younger forms in which the basal cavity is considerably smaller and located beneath the cusp.

The Ordovician forms may be included in *Prioniodina*. *Ozarkodina* intergrades with *Bryantodus* but typical forms of the latter may be distinguished by their thicker bars which have lateral flanges along the base of the denticles.

Ozarkodina denckmanni Ziegler

(Pl. 9, fig. 2, 4, 6-8)

Ozarkodina denckmanni Ziegler 1956, p. 103, Pl. 6, fig. 30-31, Pl. 7, fig. 1-2; Bischoff & Sannemann 1958, p. 99, Pl. 14, fig. 22-23; Ziegler 1960, p. 190, Pl. 15, fig. 13-15; Walliser 1960, p. 31, Pl. 8, fig. 13-14; Bartenstein & Bischoff 1962, p. 46, Pl. 3, fig. 16, Table 3; Jentzsch 1962, p. 970, Pl. 2, fig. 6; Walliser 1962, fig. 1 (32).
Ozarkodina typica denckmanni Ziegler, Walliser 1964, p. 61, Pl. 9, fig. 14; Pl. 26, fig. 3-11.

DIAGNOSIS: A flattened species of *Ozarkodina* with small expanded lips each side of the basal cavity. Cusp and denticles with strong backward inclination, distinctly flattened with occasional germ denticles interposed. Anterior limb usually slightly longer than posterior, with denticles generally increasing in size to the cusp; denticles of the posterior limb smaller, more numerous, and more uniform in height but also becoming smaller distally.

FIGURED SPECIMENS: 8797/12, 21-4.

REMARKS: The specimens illustrated have been chosen to show the variation present in the material at hand. Pl. 9, fig. 8 is typical of the species. The Tyers material agrees in all respects with previous descriptions of *O. denckmanni*. Walliser (1964) has regarded this species as a subspecies of *O. typica* Branson & Mehl, for he has found that the two intergrade in the late Silurian.

Ozarkodina media Walliser

(Pl. 9, fig. 1, 3)

Ozarkodina sp. Rhodes 1953, Pl. 23, fig. 244.
Ozarkodina media Walliser 1957, p. 40, Pl. 1, fig. 21-25; Bischoff & Sannemann 1958, p. 99, Pl. 14, fig. 15-16, 18, 19, 21; Ethington & Furnish 1962, p. 1278, Pl. 173, fig. 9; Walliser 1962, p. 283, fig. 1 (18); Walliser 1964, p. 58, Pl. 8, fig. 5, Pl. 26, fig. 19-34.

DIAGNOSIS: A species of *Ozarkodina* with limbs of approximately equal length, usually somewhat arched at an angle greater than 120°. Anterior limb generally deeper than posterior limb and carrying somewhat larger denticles. Enlarged cusp and denticles laterally flattened and basally crowded. Basal cavity wide with flaring lips (which may be somewhat asymmetrical) and continued beneath each limb as a groove.

FIGURED SPECIMENS: 8797/1-2.

REMARKS: Some of the largest specimens possess asymmetrical basal cavities which suggested comparison with *Plectospathodus robustus* Bischoff & Sannemann 1958 (p. 101, Pl. 14, fig. 11-14). In this form, however, the posterior limb is distinctly longer.

Ozarkodina sp. A

(Pl. 9, fig. 26-27)

FIGURED SPECIMENS: 8797/19-20.

REMARKS: This is a massive, slightly arched species of *Ozarkodina* with projecting lips each side of the large basal cavity. The posterior limb is lower than the anterior limb and is usually slightly longer. The denticles of the anterior limb increase in size toward the cusp and tend to be fused immediately in front of the cusp; those of the posterior limb are more uniform in size.

Among previously described Silurian and Lower Devonian species of *Ozarkodina*, this form approaches most closely *O. typica* Branson & Mehl (Walliser 1964, p. 60, Pl. 25, fig. 20-21; Pl. 26, fig. 1-2). It differs from *O. typica typica* principally in the larger, discrete denticles of the posterior limb and the tendency for those of the anterior limb to be fused. Like *O. denckmanni*, however, it could represent a form derived from *O. typica*.

Ozarkodina (?) sp. B

(Pl. 9, fig. 5)

FIGURED SPECIMEN: 8797/35.

REMARKS: Two specimens (one of which is most fragmentary) apparently represent an undescribed species of *Ozarkodina*. The unit is slightly arched and has a short anterior limb, which is bowed inward and bears a flattened denticle. The

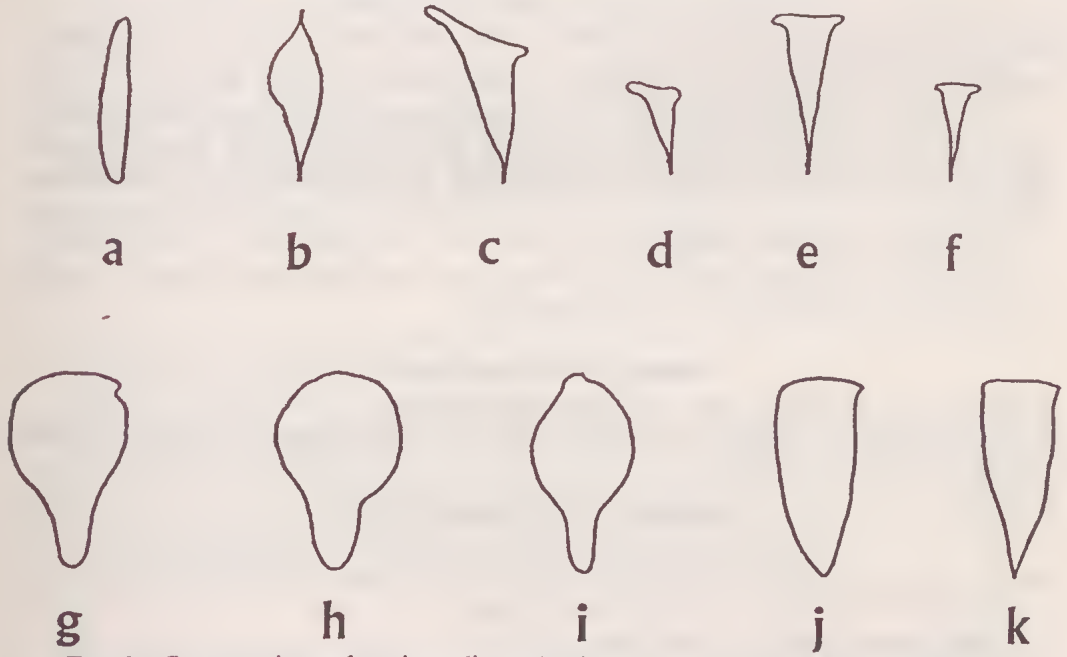

FIG. 2—Cross sections of various distacodontids and belodontids approximately at mid-height unless otherwise stated. (a) *Paltodus* sp. A. × 100. (b) *Paltodus valgus* sp. nov. × 100. (c-d) *Belodus* cf. *triangularis* Stauffer, (c) Section at mid-height, (d) Section toward distal end, × 70. (e-f) *Belodus resimus* sp. nov. (e) Section at mid-height, (f) Section toward distal end, × 70. (g) *Paltodus unicostatus* Branson & Mehl × 150. (h-i) *Paltodus acostatus* Branson & Branson × 150. (j-k) *Paltodus* cf. *recurvatus* Rhodes × 150.

posterior limb is only slightly longer than the anterior limb, and may bear up to three smaller denticles. The cusp is large, strongly compressed with a flattened outer surface and is recurved inwards. The aboral surface is deeply excavated.

This form closely resembles the Upper Silurian species *O. ortuformis* Walliser (1964, p. 59, Pl. 9, fig. 18; Pl. 24, fig. 7-13) from which it differs in its shorter anterior limb which has but one denticle.

Genus **Paltodus** Pander 1856

TYPE SPECIES: *Paltodus subaequalis* Pander 1856.

REMARKS: *Paltodus* accommodates curved fang-like conodonts with rounded anterior and posterior margins and asymmetrical lateral faces. The depth of the basal cavity is variable.

Ethington (1959) has restricted the genus *Paltodus* to Lower Ordovician species with a shallow basal cavity. He proposed the genus *Panderodus* for forms with a deep basal cavity, typified by *P. unicostatus* Branson & Mehl. Such forms range from the Middle Ordovician into the Devonian. Hass (1959) does not recognize this division of the genus. Without detailed study of Ordovician forms it is difficult to assess the value of such a separation. For the present, therefore, *Panderodus* is regarded as a synonym of *Paltodus*.

Paltodus acostatus Branson & Branson

(Fig. 2 h-i; Pl. 8, fig. 10, 23, 43)

Paltodus acostatus Branson & Branson 1947, p. 554, Pl. 8, fig. 1-5, 23-24; Rhodes 1953, p. 296-7, fig. 111-112, 163-164, 212-213.
Paltodus cf. *P. acostatus* Branson & Branson, Walliser 1960, p. 31, Pl. 7, fig. 10.

DIAGNOSIS: A gently recurved species of *Paltodus* with a deep basal cavity. Anterior edge gently rounded and somewhat flat; posterior edge more narrowly rounded and produced as a keel which narrows and fades distally. Lateral faces rounded.

FIGURED SPECIMENS: 8798/1, 3, 5.

REMARKS: Although the Tyers specimens are very large, they conform closely with previous descriptions of this species.

Paltodus recurvatus Rhodes

Paltodus recurvatus Rhodes 1953, p. 297-298, fig. 219-220.

DIAGNOSIS: A species of *Paltodus* with the cusp sharply recurved at mid-height.

Paltodus cf. **recurvatus** Rhodes

(Fig. 2 j-k; Pl. 8, fig. 18, 21)

Paltodus cf. *recurvatus* Rhodes, Walliser 1957, p. 42, Pl. 2, fig. 2-4; Walliser 1960, p. 31-32, Pl. 7, fig. 8; Fig. 9.

FIGURED SPECIMENS: 8798/8-9.

REMARKS: Rhodes (loc. cit.), in his description of this species, states that the anterior margin is rounded. Walliser has compared very similarly shaped forms with *P. recurvatus* but, in these, the anterior surface is flattened and definite angles are developed with the lateral faces. The Tyers specimens are identical in cross section with this latter form.

Paltodus unicostatus Branson & Mehl

(Fig. 2g; Pl. 8, fig. 9)

Paltodus unicostatus Branson & Mehl 1933, p. 42, Pl. 3, fig. 3; Branson & Branson 1947, p. 554, Pl. 82, fig. 6-8, 11-22; Rhodes 1953, p. 298, fig. 84-88, 155-156, 214-216; Walliser 1957, p. 43, Pl. 2, fig. 1.

Panderodus unicostatus (Branson & Mehl) Ethington 1959, p. 284.

Paltodus cf. *unicostatus* Branson & Mehl, Walliser 1960, p. 32, Pl. 7, fig. 8; Fig. 10.

DIAGNOSIS: A species of *Paltodus* similar to *P. acostatus* but possessing a somewhat shallower basal cavity and bearing a longitudinal carina along one face.

FIGURED SPECIMEN: 8798/4.

REMARKS: The material from Tyers suggests that *P. unicostatus* tends to be more slender than *P. acostatus*. Walliser (1960) expresses some reservation in identifying this species because of the absence of a cross section in the original description. There can be little doubt, however, that all the above listed forms are conspecific.

Paltodus valgus sp. nov.

(Fig. 2b; Pl. 8, fig. 7-8, 12)

DIAGNOSIS: A rapidly expanding species of *Paltodus* with a deep basal cavity. Anterior and posterior edges strongly keeled and one lateral surface marked by a low rounded ridge.

TYPE SPECIMENS: Holotype 8798/14; paratypes 8798/12, 13.

DESCRIPTION: The cusp is horn-shaped, rapidly expanding and strongly recurved posteriorly. A deep triangular basal cavity extends to $\frac{3}{4}$ of the height of the cusp. The anterior and posterior margins are strongly keeled. One lateral face is gently convex, whereas the other is strongly arched with a broad rounded ridge present toward the anterior edge. Distally the cusp becomes more rounded.

REMARKS: In its general form the species resembles *Paltodus belatus* Stauffer (1940, Pl. 40, fig. 8, 9) but the basal cavity is considerably deeper, and *P. valgus* lacks the lateral furrow of *P. belatus*. *Drepanodus* sp. of Jentzsch (1962, p. 965, Pl. 1, fig. 5-7, 9; Pl. 3, fig. 2, 13, 17) appears to be a similar, although narrower form.

Paltodus sp. A

(Fig. 2a; Pl. 8, fig. 36-37)

FIGURED SPECIMENS: 8797/10-11.

REMARKS: This is a gently expanded species of *Paltodus* with a flat inner surface and a more strongly convex outer surface. The anterior and posterior edges are very closely rounded and an ill-defined ridge may be present along the margins of the inner face. The basal cavity is deep and extends to about $\frac{2}{3}$ of the height of the cusp. Distally the cusp becomes rounded in cross section.

No comparisons can be made with previously described forms.

Paltodus sp. B

(Pl. 8, fig. 20)

FIGURED SPECIMEN: 8798/6.

REMARKS: The single specimen is a flattened cone with narrowly rounded anterior and posterior margins. The basal cavity is extremely deep. It appears to resemble most closely *Paltodus* sp. A. of Ziegler (1960, p. 190, Pl. 13, fig. 6) although in this form the cross section is triangular.

Genus **Plectospathodus** Branson & Mehl 1933

TYPE SPECIES: *Plectospathodus flexuosus* Branson & Mehl 1933.

REMARKS: This genus includes laterally compressed, somewhat arched, asymmetrical bars with an enlarged cusp. Usually one limb of the unit is twisted and somewhat curved. The basal cavity usually possesses a lip on the inner side.

Plectospathodus resembles *Ozarkodina* but differs in the twisted nature of the unit, and the lip of the basal cavity.

Plectospathodus alternatus Walliser

(Pl. 8, fig. 31-32)

Plectospathodus cf. *extensus* Rhodes, Ziegler 1960, p. 191, Pl. 15, fig. 6-7.
Sp. indet. a, Walliser 1960, p. 35, Pl. 7, fig. 14.
Plectospathodus alternatus Walliser 1964, p. 64, Pl. 9, fig. 17; Pl. 30, fig. 23-25.

DIAGNOSIS: A bladed species of *Plectospathodus* with a relatively small inwardly curved cusp. The basal cavity is small and the inner lip is not prominent. Denticles closely spaced and alternating in size.

FIGURED SPECIMENS: 8797/8, 10.

REMARKS: This is a particularly well marked species characterized by its *Hindeodella*-like appearance. Available material from other localities shows it to be particularly variable especially in the length of the anterior limb.

Plectospathodus extensus Rhodes

(Pl. 9, fig. 9-10)

Plectospathodus extensus Rhodes 1953, p. 323, Pl. 23, fig. 236-240; Walliser 1957, p. 43, Pl. 3, fig. 1-2; Bischoff & Sannemann 1958, p. 101, Pl. 15, fig. 11, 14-15; Walliser 1960, p. 32, Pl. 8, fig. 20; Jentzsch 1962, p. 971, Pl. 2, fig. 1, 5, 12; Ethington & Furnish 1962, p. 1281, Pl. 173, fig. 6; Walliser 1962, fig. 1 (19); Walliser 1964, p. 64, Pl. 8, fig. 1, Pl. 30, fig. 13-14.

DIAGNOSIS: A shallowly arched, thin species of *Plectospathodus* with laterally compressed denticles. Unit distinctly bowed outwards and the posterior limb usually the shorter with progressively reclined denticles. A basal groove extends along the aboral edge of the unit and the basal cavity has a distinct lip.

FIGURED SPECIMENS: 8797/6-7.

REMARKS: Ziegler (1960) has noted that the unit is relatively longer and the denticles more numerous in the described Gedinnian and younger forms. Ziegler also emphasizes differences in the basal cavity, the lip of which does not extend so far up the base of the cusp in previously described Devonian forms. In this respect, however, the Tyers specimens are comparable with Upper Silurian forms. The form of the basal cavity is similar to that of specimens from the Orthoceratenkalk of Tonhalde (Walliser 1957, Pl. 3, fig. 1-2). Ethington & Furnish (1962) note that, in their specimens of *P. extensus*, the basal cavity extends progressively up the inner side of the unit during growth, so that it may be that the variation seen in this feature is of no real significance. Walliser (1964) also comments on the extreme variation exhibited by the species.

Plectospathodus sp.

(Pl. 9, fig. 11-12, 23-24, 28)

FIGURED SPECIMENS: 8797/48, 59, 60.

REMARKS: Three specimens differ from *P. extensus* in being more strongly

arched, possessing much fewer and more massive denticles, and lacking a well-defined inner lip to the basal cavity.

Dr O. H. Walliser (in litt. March 1965) has suggested that these forms may be transitional between *Plectospathodus flexuosus* Branson & Mehl and *P. alternatus* Walliser, but more closely related to the former species.

Genus **Spathognathodus** Branson & Mehl 1941

TYPE SPECIES: *Ctenognathus murchisoni* Pander 1856.

REMARKS: *Spathognathodus* accommodates bladed bars with a central basal cavity which may give rise to flaring lateral lobes.

Ethington & Furnish (1962) have reviewed nomenclatorial problems associated with the genus.

Spathognathodus inclinatus (Rhodes)

Prioniodella inclinata Rhodes 1953, p. 324, Pl. 23, fig. 233-235.
Spathognathodus inclinatus (Rhodes), Walliser 1957, p. 47, Pl. 1, fig. 16-20; Walliser 1964, p. 75.

DIAGNOSIS: A simple bar-like species of *Spathognathodus*, usually with large regular denticles which may be somewhat enlarged above the basal cavity. Basal cavity variable in position and lacking prominent lateral lobes.

REMARKS: Walliser (1964) has described and illustrated the wide variation seen in Silurian representatives of this species, and considers that the Lower Devonian form *S. wurmi*, at most, should be regarded as a subspecies of *S. inclinatus*.

Spathognathodus inclinatus wurmi Bischoff & Sannemann

(Pl. 10, fig. 13-16)

Spathognathodus wurmi Bischoff & Sannemann 1958, p. 108-109, Pl. 14, fig. 4-10; Ziegler 1960, Pl. 13, fig. 12; Jentzsch 1962, p. 973-974, Pl. 2, fig. 19-20.

DIAGNOSIS: A long, bladed subspecies (?) of *S. inclinatus*, usually with greatly enlarged anterior denticles in mature specimens.

FIGURED SPECIMENS: 8797/25-27; 8798/2.

REMARKS: The specimens from Tyers resemble closely the material described by Bischoff & Sannemann (loc. cit.) from Frankenwald. The differences from *S. inclinatus* S.S. are but slight, and it may prove desirable to regard *S. inclinatus* as a synonym of this form.

Spathognathodus steinhornensis Ziegler

(Pl. 10, fig. 1-12)

Spathognathodus steinhornensis Ziegler 1956, p. 104-105, Pl. 7, fig. 3-10; Bischoff & Sannemann 1958, p. 106, Pl. 13, fig. 2-3, 7, 9; Bartenstein & Bischoff 1962, p. 44, Pl. 3, fig. 8-11; Walliser 1964, p. 85.

DIAGNOSIS: A species of *Spathognathodus* with widely flaring, usually asymmetrical lateral lobes toward the posterior end of the unit. Outer lobe usually larger and may bear irregular nodes; these may also be present on the smaller inner lobe. Posterior end usually deflected inwards and tapering; anterior end usually rather high.

FIGURED SPECIMENS: 8797/37-43, 50.

REMARKS: The abundant material available shows this to be a particularly variable species ranging from deep-bladed forms with numerous denticles through

to more robust paucidenticulate forms with ornamented lobes. The material therefore exhibits a wider range of variation than that previously ascribed to the species.

Walliser (1964) has traced a phyletic series of subspecies of this form through the Upper Silurian into the Lower Devonian of Europe. *S. steinhornensis eosteinhornensis* is replaced by *S. steinhornensis remscheidensis* Ziegler in the Lower Gedinnian which, in turn, gives rise to *S. steinhornensis* S.S. in younger Lower Devonian strata. The Tyers material is referable to *S. steinhornensis* S.S. so that the occurrence of this form, together with *Icriodus bilatericrescens* Ziegler, is indicative of an age younger than Lower Gedinnian for the Tyers fauna.

Genus **Trichonodella** Branson & Mehl 1948

TYPE SPECIES: *Trichognathus prima* Branson & Mehl 1933.

REMARKS: Included in this genus are nearly symmetrical arched bars usually with a prominent posteriorly produced lip above the basal cavity. The genus thus resembles *Roundya* and *Hibbardella* but, in these genera, a denticulated posterior bar is developed.

Some confusion exists as to the authorship of this genus, for Branson & Branson inadvertently used the name in 1947 prior to its publication in 1948 as a replacement for the homonym *Trichognathus* Branson & Mehl 1933 (non Berthhold 1827). Most European authors follow Bischoff & Ziegler (1957, p. 118-119) who ascribe the authorship to Branson & Branson. As, however, the name was first published without any discussion or indication of proposed usage it must be considered as a *nomen nudum* until it was subsequently validated by Branson & Mehl (1948).

Trichonodella inconstans Walliser

(Pl. 9, fig. 15, 25)

Trichonodella inconstans Walliser 1957, p. 50, Pl. 3, fig. 10-11; Bischoff & Sannemann 1958, p. 109, Pl. 15, fig. 20-21; Ziegler 1960, p. 35, Pl. 7, fig. 11-12; Jentzsch 1962, p. 974, Pl. 11, fig. 16, Pl. 3, fig. 19; Ethington & Furnish 1962, p. 1287, Pl. 173, fig. 7; Walliser 1962, fig. 1 (21); Walliser 1964, p. 90, Pl. 8, fig. 8, Pl. 30, fig. 10-12.

DIAGNOSIS: A species of *Trichonodella* with a thick anterior arch, the limbs of which diverge at an angle between 80° and 100°. Limbs and denticles coplanar with denticles separate, widely spaced, and round in cross section. Base of the slender, posteriorly curved cusp widened and strongly projecting posteriorly. Underside of the unit somewhat excavated and deepened under the main cusp to give the basal cavity.

FIGURED SPECIMENS: 8797/14-15.

REMARKS: The specimen illustrated in Pl. 9, fig. 25 differs from typical *T. inconstans* in its smaller basal cavity and the inequality of the length of the limbs. It is, therefore, to some extent transitional between *T. inconstans* and *Lonchodina greilingi* Walliser.

Trichonodella symmetrica (Branson & Mehl)

(Pl. 9, fig. 19, 21)

Tricognathus symmetrica Branson & Mehl 1933, p. 50, Pl. 3, fig. 33-4.
Trichonodella symmetrica (Branson & Mehl), Fay 1952, p. 199; Rhodes 1953, p. 315, Pl. 23, fig. 246; Walliser 1964, p. 90, Pl. 9, fig. 11, Pl. 31, fig. 28-30.
Trichonodella n.sp. aff. *symmetrica* (Branson & Mehl), Ziegler 1960, p. 197, Pl. 15, fig. 1-2.

DIAGNOSIS: A species of *Trichonodella* with a thin anterior arch, the limbs of which diverge at an angle of between 120° and 170°. Cusp large and triangular in

cross section, with a flattened anterior face. Limbs variable in depth and denticulation variable; usually denticles somewhat crowded. Basal cavity small, not extending up the posterior face of the arch.

FIGURED SPECIMEN: 8797/17.

REMARKS: Walliser (1964) distinguished this species from *T. excavata* (Branson & Mehl) principally on the character of the basal cavity which, in *T. excavata*, extends up the posterior face of the arch toward the base of the cusp as a prominent groove, outlined above by a posteriorly projecting ridge. The basal cavity of the Tyers specimens approaches that of *T. symmetrica*.

Trichonodella sp. nov.

(Pl. 9, fig. 29)

DESCRIPTION: The anterior arch is large with deep, strongly tapering lateral limbs which diverge at an angle of 120°. The arch is bowed anteriorly with the cusp recurved posteriorly. The lateral denticles are fused at their bases, apparently with 6 to each limb. The cusp is somewhat triangular in cross section with a flattened anterior face. Its base is widened and projects posteriorly over the small basal cavity which is confined to the underside of the cusp.

FIGURED SPECIMEN: 8797/18.

REMARKS: The single available specimen apparently represents a new species. It resembles *Trichonodella symmetrica* in the character of the cusp and the basal cavity, but in other respects it differs markedly from that species.

Gen. et sp. indet. A

(Pl. 8, fig. 1-4)

FIGURED SPECIMENS: 8797/45-47.

REMARKS: This is a small squat conical form with a widely expanded base. Similar forms have been described by Bischoff & Sannemann (1958) and by Jentzsch (1962) from the Upper Silurian and Lower Devonian of Europe. These forms were questionably referred to the Ordovician genus *Oneotodus* Lindström 1954 by these authors. *Oneotodus* Lindström is regarded as a synonym of *Drepanodus* Pander by Hass (1962). The type species of both genera are essentially fang-like cusps with a hollow base, and differ fundamentally from the remarkably squat units illustrated here.

So unusual is the form of these cones that the question is raised as to whether or not they are complete conodont units (or even as to whether they are conodonts at all). Bischoff & Sannemann (1958) ally their species with the specimen illustrated by Branson & Mehl (1933, Pl. 9, fig. 3) as *Oistodus* (?) sp., from the Ordovician Plattin Formation of Missouri. As, however, Branson & Mehl (op. cit. p. 162) describe their specimen as a 'cone of about the size and shape of the conical excavation in the base of the larger oistodids' it is clear that they regard it as a detached basal cone. Jentzsch (1962, p. 968), on the other hand, expresses some reservation in regarding the forms which she questionably referred to *Oneotodus* as conodonts.

As the substance of these cones is dark grey and shiny, similar to that of the other conodonts in the fauna, it is clear that they do not represent basal cones. However, until their internal structure is known, their conodont nature cannot be properly established.

Gen. et sp. indet. B

(Pl. 8, fig. 5-6)

FIGURED SPECIMEN: 8797/44.

REMARKS: This is a form similar to Gen. et sp. indet. A, but the upper (oral?) surface bears a compressed ridge with 4 fused recurved denticles. The form of this unit is without parallel among previously described conodonts.

Gen. et sp. indet. C

(Pl. 8, fig. 29-30, 33-34)

FIGURED SPECIMENS: 8797/51-52.

REMARKS: Two specimens in the collection do not permit confident identification. In these, the unit is distinctly plate-like and trilobate in plan. Two lobes bear lateral denticles, whereas the third lobe is smaller and bears the cusp which is strongly curved backward away from the unit. The denticles and cusp have flattened anterior faces. The aboral surface is convex and is marked by a tiny basal cavity to one side below the cusp.

In its denticulation and trilobate nature this form closely resembles the Middle Ordovician genus *Cardiodella* Branson & Mehl, particularly the type species *C. tumidus* (Branson & Mehl 1933, Pl. 5, fig. 12-14, Pl. 6, fig. 19, Pl. 7, fig. 2). In *Cardiodella*, however, the whole of the underside of the unit is deeply excavated.

Dr O. H. Walliser (in litt. March 1965) has suggested from photographs of these forms that they may represent variants of *Lonchodina walliseri* Ziegler.

Vertebrate Fragments

Occurring with conodonts in the heavy portion of the residue are a number of bony, ornamented fragments and deep rhomboidal plates. As these are the most ancient vertebrate remains recorded from the Australian continent they are briefly described and figured. Hitherto, the oldest vertebrates recorded from Australia occur in the Devonian limestones at Buchan, Victoria, and at Taemas and Goodradigbee, N.S.W. Although, in the past, a Middle Devonian age has been given to these sequences, the available evidence indicates an age not younger than late Siegenian and Emsian (Philip & Pedder 1964). These sequences, however, are significantly younger than the Coopers Creek Formation. It should be noted in this connection that the supposed cephalaspid described by Chapman (1906) from the Silurian of Wombat Ck, Victoria, is the cast in mudstone of a compound coral (Hills 1958).

The rhomboidal plates or scales may be divided into 2 categories. In the first (Pl. 8, fig. 38, 40-41) they consist of a rhomboidal ribbed crown separated from a convex base by a well-defined constriction. The lower margin of this constriction and the base of the crown are almost parallel in lateral view. Anteriorly the neck is only slightly developed. Two prominent carina run along the lateral margins of the crown and separate two sloping lateral flanges from the flat central portion of the crown. In small specimens these lateral surfaces are poorly defined (Pl. 8, fig. 40). The carina and the outer edges of the flanges merge posteriorly at a point. The anterior margin is also marked by 6 ridges which fade posteriorly.

The second type of scale (Pl. 8, fig. 39) is similar to the first except that the crown is more tear-shaped in plan view, the base is more strongly arched, the lateral flanges are absent, and the lower margin of the neck and the crown converge strongly.

These scales are of acanthodian affinities. The first group, in particular, strongly resembles those of the genus *Nostolepis* as described by Gross (1947) and by Walliser (1960). Indeed, only slight differences in shape and in the ornament of the crown distinguish the Tyers specimens. Walliser based his N. American record of *Nostolepis* on scales such as these.

Nostolepis was originally described by Pander (1856) from the Upper Silurian of the Isle of Oesel. Gross (1947) had material from the *Beyrichia* Limestone of Upper Ludlovian age in Germany. He also recorded a single specimen from the Ludlow Bone Bed. Walliser (1960), however, quotes a communication from T. Ørvig in which known occurrences of the genus are extended into the earliest Devonian.

The fragmentary ornamented plates (Pl. 8, fig. 42) occurring with the scales are usually somewhat arched which suggests that they may represent fragments of acanthodian fin spines.

References

Bassler, R. S., 1925. Classification and stratigraphic use of conodonts. *Bull. Geol. Soc. Amer.* (*Abs.*) 36: 218-220.

Bartenstein, Helmut, and Bischoff, Günther, 1962. Paläozoikum *In* Simon, Wilhelm, and Bartenstein, Helmut, *Leitfossilien der Mikropaläontologie*: 36-65, Berlin-Nikolassee.

Bischoff, Günther, and Ziegler, Willi, 1957. Die Conodontenchronologie des Mitteldevons und des tiefsten Oberdevons. *Abh. Hess. Landesamt. Bodenf.* 22: 1-136, Pl. 1-21.

Bischoff, Günther, and Sannemann, Dietrich, 1958. Unterdevonische Conodonten aus dem Frankenwald. *Notiz. Hess. Landesamt. Bodenf.* 86: 87-110, Pl. 12-15.

Boucot, A. J., 1960. Lower Gedinnian brachiopods of Belgium. *Mem. Inst. Géol. Louvain.* 31: 184-324, Pl. 10-18.

Branson, E. B., and Branson, C. C., 1947. Lower Silurian conodonts from Kentucky. *Journ. Paleont.* 21: 549-556, Pl. 81-2.

Branson, E. B., and Mehl, M. G., 1933. Conodont studies I & II. *Univ. Missouri Studies* 8: 1-156, Pl. 1-12.

———, ———, 1937. The conodont genus *Icriodus* and its stratigraphic distribution. *Journ. Paleont.* 12: 156-166, Pl. 26.

———, ———, 1948. Conodont homonyms and names to replace them. ibid. 22: 572-578.

Chapman, Frederick, 1906. A new cephalaspid from the Silurian of Wombat Creek. *Proc. Roy. Soc. Vict.* 18: 93-100.

Collinson, Charles, 1963. Collection and preparation of conodonts through mass production techniques. *Cir. Illinois Geol. Surv.* 343: 1-16.

Crespin, Irene, 1943. Conodonts from Waterhouse Range, Central Australia. *Trans. Roy. Soc. S. Aust.* 67: 231-232, Pl. 31.

Ethington, R. L., 1959. Conodonts of the Ordovician Galena Formation. *Journ. Paleont.* 33: 257-292, Pl. 39-41.

Ethington, R. L., and Furnish, W. M., 1962. Silurian and Devonian conodonts from Spanish Sahara. ibid. 36: 1253-1290, Pl. 172-3.

Glenister, B. F., 1962. Carboniferous conodonts and ammonoids from northwestern Australia. Compte Rendu 4 Congrès strat. géol. Carbonifère 1958, 31: 213-217.

Glenister, B. F., and Furnish, W. M., 1961. The Permian ammonoids of Australia. *Journ. Paleont.* 35: 673-736, Pl. 78-86.

Glenister, B. F., and Glenister, A. T., 1957a. Discovery of Silurian strata from Western Australia. *Aust. J. Sci.* 20: 115-116.

———, ———, 1957b. Discovery of Ordovician strata, Broome area, Western Australia. ibid. 20: 183-184.

Gross, Walter, 1947. Die Agnathen und Acanthodier des Obersilurischen Beyrichienkalkes. *Paläontogr.* (A) 96: 91-158, Pl. 20-9.

———, 1957. Über die Basis der Conodonten. *Paläont. Z.* 31: 78-91, Pl. 7-9.

Guppy, D. J., and Öpik, A. A., 1950. Discovery of Ordovician rocks, Kimberley Division, Western Australia. *Aust. J. Sci.* 12: 205-206.

Hass, W. H., 1962. Conodonts: *Treatise on Invertebrate Paleontology*. Part W. Miscellanea, W3-69, Geol. Soc. Amer.

HILLS, E. S., 1958. A brief review of Australian fossil vertebrates *In* Westoll, T. S., *Studies on fossil vertebrates*: 86-107, Bristol.

HUDDLE, J. W., 1934. Conodonts from the New Albany Shale of Indiana. *Bull. Amer. Paleont.* 21 (72): 1-139, Pl. 1-12.

JENTZSCH, INGRID, 1962. Conodonter aus dem Tentaculitenknollenkalk (Unterdevon) in Thüringen. *Geol. Jahrg.* 11: 961-985, Pl. 1-4.

JONES, P. J., 1961. Discovery of conodonts in the Upper Cambrian of Queensland. *Aust. J. Sci.* 24: 143-144.

LINDSTRÖM, MAURITS, 1954. Conodonts from the lowermost Ordovician strata of south-central Sweden. *Förhandl. Geol. Fören.* 76: 517-604, Pl. 2-7.

————, 1959. Conodonts from the Crug Limestone (Ordovician, Wales). *Micropaleont.* 5: 427-452, Pl. 1-4.

MÜLLER, K. J., 1959. Kambrische Conodonten. *Z. Deutsch. Geol. Gesell.* 111: 434-485, Pl. 11-15.

————, 1962a. Zur systematischen Einteilung der Conodontophorida. *Paläont. Z.* 36: 109-117.

————, 1962b. Taxonomy, evolution, and ecology of conodonts: *Treatise on Invertebrate Paleontology*, Part W, Miscellanea, W83-91. Geol. Soc. Amer.

ÖPIK, A. A., 1954. The geology of Canberra City District *In* Canberra, a nation's capital: 131-52, Aust. Ass. Adv. Sci., Canberra.

————, 1958. The geology of Canberra City District. *Bull. Bureau Min. Resour. Geol. Geophys.* 32: 1-99.

ORR, R. W., 1964. Conodonts from the Devonian Lingle and Alto Formations of southern Illinois. *Circ. Illinois Geol. Surv.* 361: 1-28, Pl. 1-4.

PANDER, C. H., 1856. Monographie der Fossilen Fische des Silurischen Systems der Russisch-Baltischen Gouvernements. *K. Acad. d. Wissen. St. Petersburg.* 10: 1-91, Pl. 1-9.

PHILIP, G. M., 1960. Victorian Siluro-Devonian faunas and correlations. *Rept. XXI Intern. Geol. Congr.* 7: 143-157.

————, 1962. The palaeontology and stratigraphy of the Siluro-Devonian sediments of the Tyers area, Gippsland, Victoria. *Proc. Roy. Soc. Vict.* 75: 123-246, Pl. 11-36.

PHILIP, G. M., and PEDDER, A. E. H., 1964. A re-assessment of the age of the Middle Devonian of south-eastern Australia. *Nature* 202: 1323-1324.

RHODES, F. H. T., 1953. Some British Lower Palaeozoic conodont faunas. *Phil. Trans. Roy. Soc. Lond.* B 237: 261-334, Pl. 20-3.

RHODES, F. H. T., and DINELEY, D. L., 1957. Devonian conodont faunas from southwest England. *Journ. Paleont.* 32: 353-369, Pl. 37-8.

RHODES, F. H. T., and MÜLLER, K. J., 1956. The condodont genus *Prioniodus* and related forms. ibid. 30: 695-699.

SWEET, W. C., TURCO, C. A., WARNER, E., and WILKIE, L. C., 1959. The American Upper Ordovician standard; I, Eden conodonts from Cincinnati regions of Ohio and Kentucky. ibid. 33: 1039-68, Pl. 130-3.

STAUFFER, C. R., 1938. Conodonts of the Olentangy Shale. ibid. 12: 411-443, Pl. 48-53.

————, 1940. Conodonts from the Devonian and associated clays of Minnesota. ibid. 14: 417-35, Pl. 58-60.

ULRICH, E. O., and BASSLER, R. S., 1926. A classification of the toothlike fossils, conodonts, with descriptions of American Devonian and Mississipian species. *Proc. U.S. Nat. Mus.* 68 (12): 1-63, Pl. 1-11.

WALLISER, O. H., 1957. Conodonten aus dem oberen Gotlandium Deutschlands und der Karnischen Alpen. *Notiz. Hess. Landesamt. Bodenf.* 85: 28-52, Pl. 1-3.

————, 1960. Scolecodonts, conodonts and vertebrates *In* Boucot, A. J., A Late Silurian fauna from the Sutherland River formation, Devon Island, Canadian Arctic Archipelago. *Bull. Geol. Surv. Can.* 65: 28-39, Pl. 7-8.

————, 1962. Conodontenchronologie des Silurs (Gotlandiums) und des tiefcren Devons mit besonderen Berücksichtigung der Formations grenze. Symposiums-Band 2 Internationalen Artbeistagung über dic Silur/Devon-Grenze: 281-7, Stuttgart.

————, 1964. Conodonten des Silurs. *Abh. Hess. Landesamt. Bodenf.* 41: 1-106, Pl. 1-32.

ZIEGLER, WILLI, 1956. Unterdevonische Conodonten in besonderen aus dem Schonauer und dem Zorgensis-kalk. *Notiz. Hess. Landesamt. Bodenf.* 84: 93-106, Pl. 6-7.

————, 1960. Conodonten aus dem Rheinischen Unterdevon (Gedinnium) des Remscheider Sattels (Rheinishes Schiefergebirge). *Paläont. Z.* 34: 169-201, Pl. 13-15.

————, 1962. Conodonten aus den Hüinghäuser Schichten (Gedinnium) des Remscheider Sattels. Symposiums-Band 2 Internationalen Arbeitstagung über die Silur/Devon-Grenze: 296-303, Stuttgart.

Explanation to Plates

All figures × 35 approximately

Plate 8

Fig. 1-4—Gen. et. sp. indet. A. (1) Lateral view of 8797/45; (2) Lateral view of 8797/46; (3) Lateral view of 8797/47; (4) Oral view of 8797/45.
Fig. 5-6—Gen. et sp. indet. B. Lateral views of 8797/44.
Fig. 7-8, 12—*Paltodus valgus* sp. nov. Outer lateral views of 8798/12, 13 and holotype 8798/14.
Fig. 9—*Paltodus unicostatus* Branson & Mehl. Lateral view of 8798/4.
Fig. 10, 23, 43—*Paltodus acostatus* Branson & Branson. Lateral views of 8798/5, 3, 1.
Fig. 11—*Hindeodella equidentata* Rhodes. Inner lateral view of 8797/3.
Fig. 13-14, 24-25—*Hindeodella priscilla* Stauffer. Inner lateral views of 8797/4, 5, 9, 11.
Fig. 15-17, 19—*Belodus resimus* sp. nov. Lateral views of 8798/17, holotype 8798/15, 8798/18, 16.
Fig. 18, 21—*Paltodus* cf. *recurvatus* Rhodes. Lateral views of 8798/8, 9.
Fig. 20—*Paltodus* sp. B. Lateral view of 8798/6.
Fig. 22, 26-28—*Belodus* cf. *triangularis* Stauffer. Lateral views of 8798/19, 21, 22, 20.
Fig. 29-30, 33-34—Gen. et sp. indet. C. (29) Posterior view of 8797/52; (30) Anterior view of 8797/51; (33) Oral view of 8797/51; (34) Posterior-aboral view of 8797/52.
Fig. 31-32—*Plectospathodus alternatus* Walliser. Inner lateral views of 8797/10, 8.
Fig. 35—*Lonchodina walliseri* Ziegler. Posterior view of 8797/13.
Fig. 36-37—*Paltodus* sp. A. (36) Inner view of 8797/11; Outer lateral view of 8798/10.
Fig. 38-42—Acanthodian fragments. (38) Posterio-lateral view of scale 8798/23; (39) Oblique lateral view of scale 8798/24; (40) Oblique lateral view of scale 8798/25; (41) Lateral view of same; (42) Fragment of fine spine (?) 8798/26.

Plate 9

Fig. 1, 3—*Ozarkodina media* Walliser. Lateral views of 8797/1, 2.
Fig. 2, 4, 6-8—*Ozarkodina denckmanni* Ziegler. Lateral views of 8797/22, 12, 21, 24, 23.
Fig. 5—*Ozarkodina* sp. B. Posterior view of 8797/35.
Fig. 9-10—*Plectospathodus extensus* Rhodes. Posterior views of 8797/6, 7.
Fig. 11-12, 23-24, 28—*Plectospathodus* sp. (11) Posterior view of 8797/60; (12) Posterior view of 8797/48; (23) Inner lateral view of 8797/59; (24) Outer lateral view of 8797/59; (28) Oral view of 8797/48.
Fig. 13, 18, 20—*Neoprinoniodus bicurvatus* (Branson & Mehl). (13) Inner lateral view of 8797/55; (18) Outer lateral view of 8797/56; (20) Inner lateral view of 8797/57.
Fig. 14—*Neoprioniodus* (?) sp. Inner lateral view of 8798/7.
Fig. 15, 25—*Trichonodella inconstans* Walliser. Posterior views of 8797/15, 14.
Fig. 16-17—*Neoprioniodus excavatus* (Branson & Mehl). Inner lateral views of 8797/54, 53.
Fig. 19, 21—*Trichonodella symmetrica* (Branson & Mehl). Anterior and posterior views of 8797/17.
Fig. 22—*Lonchodina greilingi* Walliser. Inner view of 8797/16.
Fig. 26, 27—*Ozarkodina* sp. A. Lateral views of 8797/19, 20 respectively.
Fig. 29—*Trichonodella* sp. nov. Posterior view of 8797/18.
Fig. 30-32—*Icriodus bilatericrescens* Ziegler. Oral, aboral, and lateral views of 8797/25.

Plate 10

Fig. 1-12—*Spathognathodus steinhornensis steinhornensis* Ziegler. (1) Aboral; (2) Oral views of 8797/38; (3) Lateral view of 8797/50; (4) Lateral view of 8797/37; (5) Oral view of 8797/40; (6) Oral; (7) Aboral views of 8797/41; (8) Lateral view of 8797/40; (9) Lateral view of 8797/39; (10) Oral view of 8797/37; (11) Lateral view of 8797/42; (12) Lateral view of 8797/43.
Fig. 13-16—*Spathognathodus inclinatus wurmi* Bischoff & Sannemann. Lateral views of 8797/25, 26, 27; 8798/2.
Fig. 17-18, 20-21, 24-25—*Eognathodus sulcatus* gen. et sp. nov. (17) Oral view of 8797/31; (18) Oral view of 8797/32; (20) Lateral view of holotype 8797/28; (21) Lateral view of 8797/30; (24) Aboral view of 8797/29; (25) Oral view of holotype 8797/28.
Fig. 19—*Eognathodus* sp. Oral view of 8797/33.
Fig. 22-23—*Eognathodus secus* gen. et sp. nov. Aboral and oral views of holotype 8797/34.